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**Research Report: MISI-2014-10**  
**A Framework for Measuring Carbon Emissions for Inbound Transportation and Distribution Networks**  
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# A framework for measuring carbon emissions for inbound transportation and distribution networks

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**Summary:** The thesis aims at developing a robust model that can capture, calculate and manage emissions activity across transportation and distribution network to enable corporate social responsibility practices. The research culminates in creating a scenario planning tool with cost, lead time and carbon emission as model attributes. As part of the research, literature is reviewed on best practices and methodologies and interviews conducted with functional heads, 3PL managers and experts. The created tool enables companies to gauge their emissions and identify key indicators for carbon reduction in inbound networks.



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## Introduction

Sustainable development is an increasingly important facet of the modern transportation and logistics industry, and environmental performance is fast becoming an important factor for global manufacturers. The apparel industry faces vast challenges as well as opportunities in the reduction of its environmental impact globally. Multinational companies are in need to promote efficient transport utilization and reflect regional demands that often do not align themselves with global perspectives.

There are several factors both external and internal, which demand the development of a robust Carbon Foot printing model. The growing environmental regulations and awareness has urged companies to look into its carbon emissions and optimisation policies. Besides, carbon auditing and reporting has

become a key aspect of corporate social responsibility. Industries are thus keen in improving their carbon credentials. However, for a company, its internal motives are no less significant. Initiatives aimed at sustainable development will not only identify opportunities to reduce carbon emissions but also improve operational efficiencies. The company will be able to measure changes through time.

Global consumption of clothing results in around 330MtCO<sub>2</sub> of emissions, with emissions from the use of clothing resulting in an additional 530MtCO<sub>2</sub> per year. Reduced consumption based approaches to emissions, together with production-based measures and transport optimization, could reduce emissions from clothing in developed countries by over 30% against a business as usual forecast, even with a moderate (2% pa) growth in clothing consumption

The thesis tries to approach the problem of effective reduction in carbon emission, with

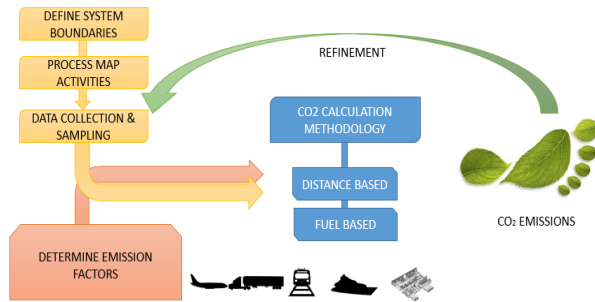


Figure 1. Carbon Emission Mapping Framework

focussed analysis of scenarios and trade-offs between model parameters. The research has been performed in three phases. The first phase deals with the mapping of carbon emission for the inbound transportation.

The second and third phase deals with scenario modelling and optimisation to obtain minimal emission with given constraints in the supply chain.

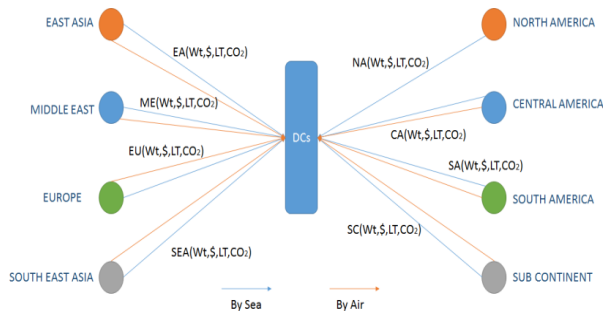


Figure 2. The Inbound distribution network

## Methodology

For the purpose of this thesis, secondary data is used along with expert opinions from the logistics and transportation industry. The research is carried over three phases. In the first phase, a carbon footprint tracking model was developed to gauge the current emissions of the sponsor company's inbound transportation. The model is developed on the Standard guidelines to measure carbon emissions. In the second phase several possible what if scenarios are created based on the industry inputs to find the prospective distribution of cargo with different modes and

zones. An algorithm to illustrate the impact of volume shift on carbon emission, cost of transportation and lead time is considered to evaluate multiple scenarios. In the third phase, based on several restrictions imposed on the cost, lead time and cargo weight limitations, an optimisation model to achieve minimum emissions is developed to find the distribution of cargo with different modes and zones. Both in phase two and three, models take in account moderate and aggressive approach to meet emission targets.

## Mapping Inbound Transportation Emission

The model is developed in sync with the guidelines from GHG Protocol, IPCC and DEFRA. The cargo weight and emission distribution over different global zones was calculated from the available data gathered. On analysis of the data it was found that road and rail played a negligible role in the transportation of inbound goods. Since most of the goods was delivered at the port by the suppliers, the road transportation has not been considered. Approximately 91% of the emission occurred due to the air transportation. Noteworthy is that 91% of the emissions came from merely 22% of the goods by weight transported by air freight. Whereas the remaining 78% of the cargo catered to 9% of the total emissions.

## Sensitivity Analysis - What if Scenario

In this section, sensitivity analysis is performed on weight distribution between air and sea mode and its impact is analyzed. The analysis is performed for eight zones with percentage weight transfer by air as the independent variable and carbon emission cost of transportation and lead time as dependent variable. Upon several rounds of discussion with industry experts, and observation of various operational and demand restrictions, the analysis was performed on a moderate and an aggressive target emission reduction.

## Optimisation Model

The objective of the optimisation model is to propose the cargo distribution by air and sea in all the eight zones based on the constraints

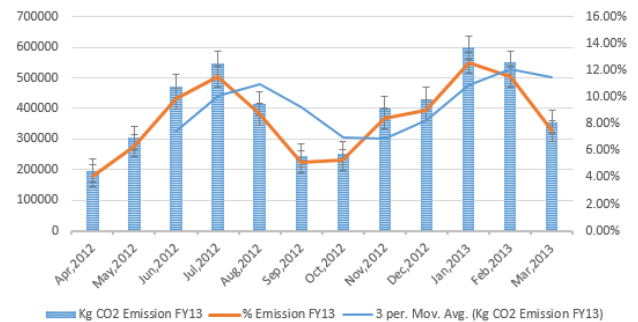
imposed on decision variables for minimum carbon emission. Here, two sets of constraints – moderate and aggressive approach – have been determined.

1. **Minimum percentage cargo that must be transferred by air:** The constraints has been determined based on the nature, cost and urgency of the product. The constraint data has been provided by the sponsor company.
2. **Percentage buffer for the increase or decrease in the transportation:** The constraint allows the user to set an upper limit to the cost in respective zones.
3. **Lead Time Buffer:** The constraints allows the optimiser to put a boundary condition to the flexibility in delivery times. It is in the form of percentage of current lead time index. The constraint has been determined by analysing the What-if scenarios.

## Discussion

On a closer analysis of the distribution on the basis of zones, it was seen that cargo transportation from South America was the highest contributor with 29%, followed by 20% by Europe and 13% by East Asia. However, this figure did not give a clear picture unless viewed against the mode and weight distribution in particular zones. A weight percentage of 3.51% by air and 0.09 % by sea coming from South America is responsible for the 28.84% total emission due to inbound transportation. The 20% emission from Europe comes 4.27% weight by air and 0.13% weight by sea. It is also seen that the emission by air transportation is 32 times more intense than by sea transfer in South America and 18 times more intense in East Asia.

The month of July and January witnessed the highest contribution to the annual emissions by 11.49% and 12.55% respectively. The three month Moving Average also followed a similar pattern as depicted in Figure below.



The author studied the 25 scenarios for each zone. Each scenario in the sensitivity analysis reflected the change in the CO<sub>2</sub> emission (CO<sub>2</sub>), cost of transportation (COT) and lead time (LT) depending on the reduction in the weight transported by air.

While few of the observations were as expected, there were slight variation in the trend line of others. In all the cases as seen in the graphs below, the lead time increased with decreasing shift of the percentage transfer by air. The CO<sub>2</sub> emission decreased with increasing shift of percentage shift by sea. The cost of transportation showed different phenomenon with zones. For East Asia, the cost of transportation marginally increased with increasing use of cargo transfer by sea. A similar phenomenon was observed for the cargo transfer from South America where the cost of transfer tend to increase with sea routes, however the CO<sub>2</sub> emission significantly dropped. The cost followed the CO<sub>2</sub> emission i.e. decreasing trend for Central America and North America.

## Conclusion

The thesis, based on the guidelines of WRI WBCSD and research studies in the field of carbon footprint, provides an insight into the impact of ‘redistribution of cargo weight between air and sea transportation’ on carbon emission, cost and lead time variations. The study has been conducted in three phases. The first phase develops a model to determine the carbon emission from freight transportation from eight global zones to consolidated DCs in

East Asia. Secondary data has been used with expert opinions from the transportation and logistics industry in order to achieve the objectives. In the second phase of the study, a scenario thinking tool has been developed, which helps to gauge the respective change on carbon emissions, cost of transportation and lead-time with the shift of cargo from air to sea mode and vice versa. This tool gives the liberty to adjust the parameters for all zones separately and furbishes the results for global impact.

Based on survey and consultation with industry experts, two cases are considered – a moderate and an aggressive approach. Both cases provide an estimated drop in emission by 16.15% and 30.87% respectively and increase in lead-time by 7% and 12% respectively, with less than 2% variation in the cost of transportation. In the third phase, the weight distribution across modes and zones, has been optimised to minimise the carbon emissions from the global inbound transportation. Constraints such as minimum weight transfer by air mode, buffer on transportation cost and maximum lead-time flexibility have been built in. Again, optimisation is performed on the moderate and aggressive cases to give 11% and 17% drop in emissions respectively.

The study focussed on the inbound transportation highlights carbon mapping measures in East Asia. The research qualifies the fact that modal shift to energy-efficient modes can substantially help to reduce carbon emissions from freight transport. Fashion industry is highly sensitive to the availability of the seasonal products in store. It will be interesting to further study the impact of different lead-times on the service level, in view of carbon emission. Since the fashion industry comprises of high value products, it will be worth tabulating the carbon emission based on the worth of products. The author is aware of the limitations of the research, which make it a significant arena for further research. The limitation of the framework demanding

immediate attention is cost of goods transported and the impact of the lead-time variation on the revenue. This variable when incorporated in the framework will most likely provide a different set of results and allow for more robust insights. The practice of slow steaming in the shipping industry might pose interesting opportunities in emission reduction and variations in the lead-time.